BOOK DEPARTMENT.

CONDUCTED BY PRINCIPAL C. H. THURBER.

Pioneers of Science. By OLIVER LODGE, F. R. S., Professor of Physics in Victoria University College, Liverpool. pp. xv, 404. London: Macmillan & Co, 1893. Price $2.50.

This book, finding its origin in a course of lectures delivered by the author, aims to do for the great names inseparably connected with the science of astronomy what has already been done by the *Heroes of Science* for the great botanists, zoologists, and geologists. Within a comparatively small volume, the author has given a clear idea of the various phases of the struggle through which the science has developed from the first serious questioning of the Ptolemaic System down to the latest theory of planetary evolution. This is done by a graphic treatment of the life work and, incidentally, of the times of Copernicus, Tycho Brahe, Kepler, Galileo, Descartes, Newton, Roemer, Bradley, Lagrange, Laplace, Herschel, Olbers, Bessel, Adams, and Leverrier. The work is divided into two sections: Part I, *From Dusk to Daylight*, closing with the life and work of Newton; and Part II, *A Couple of Centuries of Progress*, covering the ground from that point to the present time.

The men whose lives are described have been selected in accordance with the author's views as to what constitutes the character of a pioneer. A pioneer, he says, is one who is influenced "directly by the universe around him, has felt at times overpowered by the mystery and solemnity of it all, and has been impelled by a force stronger than himself to study it patiently, slowly, diligently; content if he could gather a few crumbs of the great harvest of knowledge, happy if he could grasp some great generalization or wide-embracing law, and so in some small measure enter into the mind and thought of the Designer of all this wondrous frame of things." Such are "the great and heaven-born men of science" who have proved to be the epoch makers in the slow growth of knowledge, and who stand out in sharp contrast with the great majority that to-day, as well as in the past, study science to gain some sordid or selfish end. Measured by this ideal, not all of the men spoken of in the book deserve the term pioneer, and could more be known of them, some of the earlier astronomers deserve a more conspicuous place.

After brief notice of Archimedes and Leonardo Da Vinci, the au-

thor really begins with Nicolas Copernik, the publication of whose work in 1543 marks the dawn of modern science. In this connection, there is brief reference to the cosmogony of the Greeks, the Egyptians, and the Hindoos; and the main features of the Ptolemaic system are set forth with as great clearness, perhaps, as the space will admit. In an effort to simplify the explanations of planetary motion offered by the Ptolemaic system, Copernicus took the first decided step towards its overthrow by proving that the sun, not the earth, is the center of the solar system.

The entire change of front wrought in the science of astronomy by Copernicus gave impulse and direction to the work of Tycho Brahe, who brought to the service of the new theory a wealth of accurate observation which secured it forever from overthrow. Tycho's theory that the planets revolve around the sun, and that it and they revolve around the earth seems like the last gasp of the Ptolemaic idea, and it did not engage serious attention; but the instruments that he devised, the observatory he established on the island of Huen, and the splendid use his genius enabled him to make of the munificence of Frederick II of Denmark, give his life and work a prominence and character the importance of which can hardly be overestimated.

It is the suggestion of law which gives intelligent direction to thought; and in the waning years of Tycho Brahe there became organically associated with his work a man, not eminent as an observer, but of a speculative mind, and peculiarly fitted by nature as a mathematician to give to Brahe's observations a wonderful interpretation. This was Kepler, who, though physically delicate, performed almost incredible labor, and, mainly from Tycho's observations, discovered the three laws of planetary motion, thereby demolishing the last vestige of the old astronomy and ushering in the new.

Law I. Planets move in ellipses with the sun at one focus.

Law II. The radius vector sweeps out equal areas in equal times.

Law III. The square of the time of revolution of each planet is proportional to the cube of its mean distance from the sun.

Through the life of the great contemporary of Kepler, Galileo Galilei, the author gives us a vivid picture of the spirit and character of the times. The period is from 1564 to 1642. The doctrines of the monk Copernicus, a hundred years before, now found philosophic expansion in the pantheism of Bruno, and his predictions, a verification through the inventions and consequent discoveries of Galileo. By his invention of the telescope, the idea having been derived from a toy constructed by a Dutch optician, Galileo was enabled to extend widely the domain of observation in the heavens. He discovered Jupiter's satellites, studied the surface of the moon, explained earth-shine, noted the phases of Venus, and discovered spots on the sun. He laid the foundation of mechanics by the discovery of the laws of motion, and demonstrated from the tower of Pisa that, under the influence of gravity

alone, all bodies fall with equal rapidity. His work on motion, accomplished chiefly in the last years of his life, after he had been compelled under torture to recant, and after he had become blind, the author regards as his most important achievement.

Following a brief but interesting review of the times, the author selects the life work of Descartes as that which best fills the gap between Galileo and Newton. His speculations leading to the theory of vortices have present value, chiefly as an object lesson in deductive methods of study; his application of algebra to geometry, however, made possible the *Principia* of Newton. In the three following chapters the author gives an interesting account of the work of Newton. While a good deal of this is beyond the grasp of the non-mathematical reader, yet even he will gather from the excellent summary of Newton's labors, given at the close of the history, a fair idea of the magnitude and importance of his work to science. The author says that the immediate effect of Newton's colossal achievements was to overwhelm his successors with a feeling of impotence and helplessness that paralyzed their efforts for a century.

The next problem of conspicuous importance which receives attention is that concerning the velocity of light. From Galileo down, the solution of this had defied the efforts of physicists; but Roemer, a Dane (1644–1710), by a proper interpretation of an observed variation in the time between the successive eclipses of one of Jupiter's satellites, determined approximately the rate at which light travels. Bradley, Professor of Astronomy at Oxford, fifty years later discovered the aberration of light, and confirmed the results reached by Roemer concerning its velocity. The splendid mathematical genius of Lagrange and Laplace was devoted to working out the higher problems of astronomy in accordance with the theory of gravitation. They proved the stability of the solar system, and that its inequalities are periodic and not cumulative; that all the changes will not have taken place until a period of two million years has passed. The brilliant speculation of Laplace which resulted in the formulation of the Nebular Hypothesis stands to-day as the most probable theory yet presented in explanation of the origin and development of the solar system.

Up to this time, the attention of astronomers had been directed mainly to the members of the solar system; it remained for William Herschel, aided by his sister Caroline, to bring the distant and fixed stars, so-called, into the domain of observation. He began the science of the stars. He discovered and catalogued twenty-five hundred stars, discovered the motion of the fixed stars, and showed that our sun is moving towards a point in the constellation Hercules.

In succeeding chapters, the author traces the triumphs which have come to astronomy by the application of mathematics to physics. The most striking and interesting result of this was

the discovery of Neptune through calculations based upon the observed perturbations of Uranus. These calculations were carried on by Leverrier in Paris and Adams in Cambridge, each unknown to the other, and, in exact accordance with their predictions, the planet was seen for the first time, knowingly, by Galle in Berlin. The book devotes one chapter to comets and meteors, and closes with two well written chapters on the theory of tides and planetary evolution.

Although the book in certain parts is too technical for the average reader, yet the general plan and method of treatment are excellent. The author shows how by careful observation, rational speculation, and accurate calculation, the science of astronomy has come to be the substantial structure it is; he gives vivid portrayal of the struggles undergone and persecutions suffered by those who had to pay the penalty or price for the position of leadership in the world, and by graphic description he gives the attentive reader some wonderful glimpses into the infinity of the universe about him. It is a book of enduring value for the library of either home or school.

Wilbur S. Jackman.

Cook County Normal School, Englewood, Ill.

Greek-English Word List. By ROBERT BAIRD, Professor of Greek in Northwestern University. Ginn & Company: Boston. 1893. pp. 42.

Every classical teacher has regretted many times that students almost universally learn the story rather than the words. Oftentimes when the translator reads most glibly, if he is asked for the meaning of words apart from their connection, he is found wofully ignorant. The enormous waste of time which this shiftless method of study produces is deplored alike by teachers and students; but still the shiftlessness continues and a half million or more lexicons and vocabularies are daily becoming needlessly worn and soiled by too frequent thumbing. None of the devices hitherto suggested for preventing this waste are satisfactory. They are either totally ineffectual or else require too much time.

Now there are four things which it is desirable to know about a Greek word: first, its general meaning—the concept which it should call up; second, its special meanings, idiomatic and figurative; third, its relation to other Greek words—its root and various differentiations; and fourth, its relation to Latin and English. It is desirable to know these four things in regard to a word just as it is desirable in regard to a friend to be acquainted with his character, his special tastes and aptitudes, his family connections, and his relation to society.

The little book under review helps us toward this quadruple acquaintance. Its forty-two pages contain two lists of about one